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FILING DATE: ***January 21, 2004***
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

INVENTOR(S)

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☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

PREFORMATTED RECORDABLE LINEAR STORAGE MEANS AND MANUFACTURING METHOD

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☒ Firm or Individual Name	Toby H. Kusmer				
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ENCLOSED APPLICATION PARTS ***(check all that apply)***

☒ Specification *Number of Pages* 10
☒ Drawing(s) *Number of Sheets* 5
☐ Application Data Sheet. See 37 CFR 1.76
☐ CD(s), Number ____
☒ Other (specify) Postcard, Check

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☒ Applicant claims small entity status. See 37 CFR 1.27.
☒ A check or money order is enclosed to cover the filing fees
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Respectfully submitted,

SIGNATURE Toby H Kusmer

Date 1-21-04

TYPED or PRINTED NAME Toby H. Kusmer

REGISTRATION NO. *(if appropriate)* 26,418

TELEPHONE 617-535-4065

Docket Number: 59380-017 ~~(MCMK-4A-PR)~~

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (8-00)
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Docket Number	59380-017(MCMK-4A-PR	Type a plus sign (+) inside this box ⟶	+

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CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10) Applicant(s): W. Dennis Slafer		Docket No. 59380-017 (MCMK-4A-PR)	
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Invention: **PREFORMATTED RECORDABLE LINEAR STORAGE MEANS AND MANUFACTURING METHOD**

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is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

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Title: Preformatted Recordable Linear Storage Means And Manufacturing Method

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Assignee: MicroContinuum, Inc.

Internal Docket Number: MC004

BACKGROUND

All current optical storage discs, including CDs, DVDs, and magneto-optical discs, contain physical relief structures that are read by the optical head and are used for position and tracking information, among other things. These structures consist of very fine surface modulations (often in the form of pits, bumps, grooves or lands, etc.) typically containing features having dimensions in the submicron down to the nanometer region and are created during the injection molding process by which such discs are manufactured. The process of incorporating these features into the substrate of an information medium during the manufacturing process, by this or similar replication process, is often referred to as "preformatting". A major benefit of preformatting includes very efficient utilization of the disc surface, which translates into higher storage capacity and performance improvements compared to media without pre formatting. The clear advantages of preformatting of optical discs are borne out by the fact that early optical discs with unformatted (smooth) surfaces have been universally replaced by discs with preformatted surfaces.

A number of attempts have been made to apply similar enhancements to magnetic tape media in order to improve its areal density and performance. Prior art includes the use of magnetic heads to write simple tracks and the like, in which the resolution and accuracy is limited in these examples due to the limited resolution of the magnetic heads themselves, and these format features are susceptible to accidental erasure as well. Attempts to improve upon these limitations include the use of lasers to etch guide tracks on the tape (US6,433,951,B1, US6,480,351 B2, etc.). These processes, however, also suffer from significant limitations, including additional manufacturing costs, and not the least of which is the format resolution is limited by the wavelength, precision, and accuracy of the writing laser, which is usually much coarser than the very short wavelength laser used in the disc preformatting process. Thus the areal density (storage capacity per unit area) of even such "servo-guided" tapes is significantly below that of optical discs.

Prior art related to creating physical features on tape-like substrates include US05045676, which discloses an card medium that might also be manufactured as a tape and describes optical patterns consisting of discrete interlocking rings disposed along the length of substrate. This has a number of disadvantages and limitations, including very inefficient use of surface area, since only the area containing the ring pattern is useable, with much area wasted. Furthermore, the possible use of this medium in a tape cartridge configuration, as suggested in the invention, requires that the entire cartridge to be spun at high rotation rates about an axis going through the hypothetical center of a given disc pattern. This is a very complex, costly, and impractical procedure insofar as the difficulties involved in rotating a rather large, unbalanced mass (particularly with different amounts of tape are on either spool) precisely about a virtual center while maintaining acceptable runout, balance and tensioning. Alternatively, using a spinning optical head or mirror arrangement, etc., at high rotation rates would likewise be impractical for a number of reasons. These critical issues are neither discussed nor taught by the invention.

Additional prior art includes methods for duplicating magnetic tape (US4,882,637), which is useful only for replicating magnetic bits with the same resolution limitation as the magnetic tape from which it is copied and which does not create features that can be easily read by means of optical head.

Other prior art (5,872,758) describes a read-only tape that is formed from a pattern spiral-wrapped around a cylinder. This media, however, is neither recordable nor capable of extended tape lengths due to the limited amount of tape that can be spiral wrapped around the cylinder. For example, to make a tape 1,000 meters long in standard 1/2-inch width would require a 3-foot wide drum that is 13 ft in diameter, which would be quite expensive. Further, this tape requires slitting in a diagonal fashion by an extremely complex slitting means which is not fully taught by the invention.

The present disclosure has been developed to substantially eliminate the shortcomings and disadvantages of the prior art, as noted above, and thereby provide a preformatted recordable linear storage medium and a method for its manufacture.

DESCRIPTION

The disclosure relates to a recordable linear storage medium which incorporates essentially continuous, linear preformatted features so as to efficiently utilize the surface area of the medium, and also describes a method for manufacturing such.

The storage medium described herein is characterized by a thin (in the approximate range of 4 microns to 100 micron), elongated tape-like substrate having a plurality of features on at least one surface in order to provide position, tracking, etc. information to an optical head or pickup unit, and which substrate can also contain additional layers to facilitate reading or writing of user data on one or both surfaces. The recording layer(s) belong to a class or classes of materials known to the art that changes one or more physical properties in response to exposure to laser or other actinic radiation, including particularly such radiation as would be emitted from an optical disc head. The aforementioned class of materials include phase change and dye-polymer media.

In order to describe the benefits of preformatting linear storage media, a comparison can be made to a typical common optical disc type, the DVD. It can be seen from a geometrical analysis that the useable area of a typical 120 mm diameter optical disc (93 cm2) is equivalent to about 3/4 m of a standard (12.5 mm) width tape. Thus, by incorporating a DVD-like format (and using appropriate optical heads, etc.) into the tape medium of this disclosure, the total storage capacity of a single cartridge containing 1,000 m of standard 1/2-inch tape, for example, would be 6,300 GB (6.3 terabytes, or TB). For comparison, a single surface of a typical DVD holds 4.7 GB of information.

According to another aspect of the disclosure, a method is described for manufacturing this storage medium which includes use of a patterning tool which imparts an essentially continuous and seamless linear pattern of the desired format structure into the surface of the substrate. The patterning tool is of cylindrical or continuous belt-like geometry and may contain concentric or spiral tracks, or any other desired geometry on its outer surface. The axis of rotation of the tool is generally parallel to the substrate plane and perpendicular to the long dimension of the substrate. During the continuous replication process by which the tool pattern is replicated into the surface of the substrate, substrate material is supplied to the tool from an unwind spool by a mechanical transport/control process and is subsequently rewound onto a take-up spool following preformatting.

According to another aspect of this disclosure, the use of chemical softening agents that act on the substrate or specific component or layer of said substrate, followed by the optional use of thermal energy to rapidly reverse the effects of said chemical agents when in contact with the pattern tool, results in a rapid resolidification and therefor accurate reproduction of said pattern, which in turn enables high production rates. It may also be appreciated that certain aspects of this process this may be useful in manufacturing disc-like storage substrates as well.

It is also an aspect of this disclosure that the chemical softening agent as mentioned above can be replaced by a polymeric material that can be hardened by exposure to

the appropriate radiation, such as is known to the art, where the radiation source is of an appropriate wavelength to cause the polymer to become solid prior to separation from the replication tool.

According to yet another aspect of this disclosure, it is also a useful feature of the replication process described herein that a range of dye polymer-based recordable layers can be incorporated into a controllable portion of the patterned substrate layer simultaneous with the creation of the format features, thereby allowing the eliminating a subsequent process step for incorporating such recordable layers. This is accomplished by dissolving a dye, such as is known to the art of CD-R manufacturing, into the polymer-softening chemical, where the dye and chemical are chosen for chemical compatibility. The short time of simultaneous contact between the substrate, tool, and dye solution at this point of intersection, called the "nip", causes the dye to imbibe into the top surface of the substrate and precisely follow the profile of the format features. This characteristic nip action causes the dye to be concentrated at the surface of the polymer such that radiation from a laser source, for example, is highly absorbed in this portion of the substrate and can thereby cause a marking action to the substrate by the impinging radiation. Such a storage material can operate in the transmission mode or, by application of a reflective coating, in reflection mode from either side of the substrate. It may also be appreciated that this process is not limited to a tape-like format, but is useful in disc-like storage substrates as well.

According to one aspect of the disclosure, the use of a format containing DVD-like format features enables reading and writing of said medium with DVD heads, having electrical and/or optical modifications as necessary to accommodate modifications or improvements of the embedded format. Due to the linear nature of these features, the use of multiple optical heads or groups of heads is also disclosed. The use of existing electro-optic components, such as optical disc heads incorporating auto focus, servo tracking, etc., greatly reduces the cost of the read-write head(s) in the companion drive hardware for this tape format.

According to yet another aspect of the disclosure, the preformat structures of the linear medium can include a wide variety of features, including lands, grooves, pits, data and ROM information, etc. Such features can be either recessed or proud relative to the plane of the substrate, and can be in the nanometer regime of critical dimensions.

It is also an aspect of this disclosure that both sides of the linear medium can be utilized, such as having a recordable or ROM layer on either or both sides, or layers with different functionalities (WORM, erasable, ROM) on different sides. Also, such preformated media may utilize both optical and magnetic optical media. For

example, using the preformat structure for servoing and magnetic heads for reading and writing to a magnetic layer.

These and other objects and features of the disclosure will be more clearly apparent from the following description when taken in conjunction with the accompanying drawings briefly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a schematic of the process by which the preformat elements are formed into the substrate.

Fig. 2a and 2b show cut-away views of preformatted disc substrates.

Fig. 3 shows a normal incidence view of wobble land and groove recording used in certain types of DVDs discs.

Fig. 4 shows a perspective sketch the focussed beams from multiple optical heads incident on the of a section of preformatted optical tape.

Fig. 5 shows a schematic of the process by which the recordable layer is applied.

DETAILED DESCRIPTION

The following description refers to several possible embodiments of this disclosure and it is understood the variations and methods described herein may be envisioned by one skilled in the art, and such variations and improvements are intended to fall within the scope of the disclosure and therefore the invention and methods are not limited to the following embodiments.

Referring to Fig. 1, an unwind spool (not shown) feeds the smooth polymeric substrate 1 into the preformat forming zone 3, whereupon the substrate is placed in contact with the rotary tool 4 having the mirror image of the desired format pattern 5. The preformat structure is formed by applying by means of dispenser 6 a softening chemical 10 onto the surface of said tool such that the rotation of the tool brings the chemical into contact with substrate 1 at position 2 (the "nip"). A semi-solid surface layer results from contact of the outermost surface of the substrate with the softening chemical 6, and the amount of the softening chemical that imbibes into the polymeric layer is controlled by the metering action and pressure exerted by elastomeric backing roll 11, which is engaged against back side of substrate 1. In order to accurately reproduce the format features by this process, it is necessary to resolidified the softened polymeric surface while still in contact with the tool,

otherwise the features will be distorted due to material flow after tool separation. Thermal radiation is supplied by source 7 to resolidify the surface by accelerating the rate of diffusion of the chemical away from the layer in direct contact with the format tool, resulting in rapid resoldification prior to tool separation. After withdrawal of the now-patterned substrate 5 from the tool surface at position 8, said separation being facilitated by backing roll 12, the preformatted substrate is wound onto take-up spool (not shown). It is an important feature of this procedure that the rapid resolidification of the polymer resulting from the enhanced diffusion allows high manufacturing process speeds.

In another embodiment of the process, the softening chemical in 6 can be replaced with a liquid polymeric material that can be hardened by radiation, such as is known to the art, where the radiation source 7 is of an appropriate wavelength to cause the polymer to become solid prior to separation from said tool. Use of such a liquid polymer has the additional benefit of simultaneously filling and planarizing the substrate during the time that the substrate, polymeric material, and tool are in contact. This can, among other things, compensate for scratches and non-uniform substrate surface features. A liquid polymer also offers the advantage that the physical and chemical properties of the substrate and polymer material can be chosen with some degree of independence, which allows each component (the substrate and the polymer layer) to be optimized according to the requirements of each (for example, optimizing the substrate for physical strength and tear resistance, and optimizing the polymer layer for ability to replicate fine surface details).

It is an aspect of this disclosure that any of the above-described preformatting processes, when used with a precision continuous and seamless preformatting tool having essentially linear format features, and subsequent coating of a recordable layer, can produce a preformatted linear information-carrying and/or recording medium of any arbitrary length or width.

It is also an aspect of this disclosure that the preformatted linear substrate may be coated with a layer or layers that enable the recording of information on the substrate. This includes, but is not limited to, write-once (WORM), erasable, dye-polymer, and the like, or any combinations thereof. The recordable and/or erasable layers can be based on phase change (US4981772, US5077181), dye-polymer (US 5382463), or any such layer or layers that are sensitive to the radiation of the appropriate optical head.

Other embodiments of the linear storage means of this disclosure may incorporate other recording and information encoding schemes as are known to the art, including but not limited to grayscale (multi-level), nearfield, fluorescent, volumetric, holographic, or any other such means (e.g., ISOM/ODS *Conference on Optical Data Storage*, July 2002, HI).

It is also a useful feature of this disclosure that the recordable layer can be embedded into the polymer layer simultaneous with the creation of the format features, thus eliminating an additional process step. This is accomplished by dissolving a dye, such as is known to the art of CD-R manufacturing, into the polymer-softening chemical, where the dye and chemical are chosen for chemical compatibility. The short imbibition time of the dye into the polymer resulting from the high-speed contact of substrate and tool causes the dye to precisely and closely follow the profile of the format features, such that radiation from a laser source, for example, is highly concentrated at the surface of the polymer and can be thereby marked by action of the impinging radiation. The effect can be amplified by application of a reflective coating such that the dye layer is addressed and reflected radiation detected from the second (substrate) side.

Now referring to Figures 2a and 2b, perspective sketches are given that illustrate format details of several of the patterns that are used in current optical discs (e.g., DVDs). These types of format patterns and the appropriate optical disc head and electronics, when used together, form the basis of optical disc data storage systems currently used for data or video and the like. Such land and groove or groove formatting schemes, for example, may be implemented in the linear media of this disclosure, and therefore can be also be read and written by the appropriate optical pickup unit and electronics for which such devices were designed. Appropriate modifications can be made to account for the differences in media as seen by the optical head, including compensation for differences in optical path length caused by the thinner cover layer in the tape relative to the disc. Such modifications may include, for example, placing a small piece of material, such as polycarbonate, in the optical path of the lens in order to provide the requisite 0.6 mm optical path length, in the case of the DVD, for which the pickup optics were originally designed. Changes in detection signal polarity (for write bright versus write dark recording schemes) or tracking/servo electronics (to compensate for format changes necessitated by the linear track structure) may also be applied to such "off-the-shelf" opto-electronics units.

Fig. 3 shows a detailed illustration at normal incidence of the disc formats of Fig 2a and 2b. It will also be appreciated that other format schemes may also be employed. It can be seen from these illustrations that such formats can exhibit a great degree of complexity, including lands, grooves, wobble grooves, pits and various fine structures, all contributing to the ability of such formatted media to achieve very high storage densities. Such features are not readily created by use of high-throughput post-manufacturing formatting processes.

Fig. 4 is a sketch of a magnified section of the preformatted media of this disclosure after the recordable and overcoat layers have been applied, showing the interaction of the light beams 31 from several optical pickup units. One particular embodiment of this disclosure includes a composite substrate consisting of a carrier layer 30 (such as polyethylene terephthalate, PET, polyethylene naphthalate, PEN, or other) which is selected for physical strength, durability, etc. and a polymer layer 34 (such as polycarbonate, acrylic, cellulose acetate butyrate or the like), which is selected for replication of the format features with high resolution. An additional layer may be useful with certain combinations of carrier and polymer layer to provide enhancement of adhesion between the carrier and polymer layer. Also not illustrated in this figure is the backcoat, which would generally be included in this medium as useful in friction, heat, and static electricity control. This illustration generally depicts an example of one of several formats known to the art as used in DVD and CD discs, in which the surface of the substrate contains lands and groove features whose side-walls are wobbled (33) for tracking purposes and which contains other format elements. The layers indicated by element 32 in this embodiment represent several layers of thin-film coatings that comprise the phase change stack, and may consist typically of from 1 to 5 or more layers, which can include the following layers, in order from the read/write incident surface, there first being a protective overcoat layer (polymeric or inorganic), an outer dielectric layer, a phase change recording layer (typically a Te alloy), another dielectric layer, and a reflection/thermal control/nucleation layer. The aforementioned individual layers of such a phase change stack are known to the art as might general constitute rewritable and/or write-once layers as used in CDs and DVDs. It should be noted, however, that in the embodiment of this disclosure, the order, thickness and composition of said layers are different that those used in optical discs, wherein the latter case such layers are designed to operate as second-surface (substrate-incident) devices. It should also be noted that the layers can be varied in number, composition, thickness, etc. to operate in a write once or erasable mode.

The media of this disclosure may also include one or more coatings on the side opposite the format side, these layers usually being referred to as backcoat(s). In the one embodiment of the storage media described herein, the backcoat layers may include single or multiple layers and be may be used for friction and/or surface control. This functionality describes the substrate's interaction with the film support/guide member (over which the substrate moves during the read/write process), and the front media surface to back media surface contact as occurs on the unwind and rewind spools. Friction control may include the use of specific surface textures and materials on the back surface, either by application of a layer to provide such surface quality, embossing such a texture to said surface, or use of additives in a coating process to create the desired texture. The same, or similar, surface replication process as used to create the format on the front surface can be used to create a specific texture on the back surface..

Another embodiment of this disclosure is use of the backcoat for thermal control. This is done by selecting the backcoat material for optimal thermal conductivity, among other things. Coatings with appropriate thermal properties can be applied by vacuum deposition (such as metallic coatings, for example), as well as by aqueous or solvent coating processes known to the art, or by application of radiation-cured polymeric materials into which thermal control additives may optionally be included for (in addition to the previously-mentioned texture control purposes).

Another use of the backcoat is for dissipation of static electricity. An embodiment of this disclosure is the use of vacuum-deposited electrically conductive coatings (such as metals and transparent conductive materials including indium-tin oxide) to achieve this end. It should also be noted that these and other benefits of the backcoat can be combined, such that one or more layers can be used to produce, as just one example, a textured surface with an metallic vacuum deposited overcoat that is beneficial for friction, thermal, and static electricity discharge.

It should also be noted that the thermal, electrical, and friction control that is afforded by single or multiple applied backcoat layers can also be accomplished by incorporation of polymeric or inorganic materials into the substrate itself, or co-extruded during the manufacturing process thereof.

In Fig. 5, details are given of the process of the preferred embodiment by which the recordable phase change layers are applied to the formatted substrate 14. This sketch illustrates a 3-layer deposition process, which might be used, for example, for a write-once phase change formulation (but which could also include fewer or additional deposition, depending on the exact functionality desired). It is important to note that standard recipes in the prior art for such layers, particularly of the Ge-Sb-Te phase change type, are designed for optical disc applications, utilizing second surface (substrate-incident) recording. Such a second-surface sensitive layer structure, however, will not work for first surface ("format-incident") media and must be substantially modified for use in first-surface media such as the present disclosure. For example, the layer structures appropriate for the media of this disclosure in a phase change WORM (write-once) embodiment require that the reflector (or nucleating) layer be deposited first, directly on the formatted surface of the substrate, followed by the phase change alloy layer, and followed in turn by a protective layers (or layers). Furthermore, the layer thickness and composition need to be optimized for first-surface recording, including such factors as layer thickness, thermal conductivity, refractive indices, etc.

The device in this embodiment for applying the phase change layers to the formatted substrate comprises a vacuum chamber 17, an unwind spool 14 which supplies formatted substrate to the vacuum coating zones 16 containing a multiplicity of independent deposition sources, the number and composition being dependent on

the specific functionality desired (write-once, erasable, ROM), and a rewind spool 15. As previously mentioned, the last layer as seen by the incident light beam (typically a refection/thermal control layer in a write-once embodiment), 18, is applied first. The second layer, which is the phase changer alloy, is deposited in the next zone 19, followed by the third (protective) layer in zone 20. It should be noted that as few as one layer, or as many as 5 or more may be required for the phase change recordable layer.. Also, additional layers may be added, either by vacuum or other process, such as solution coating, to either or both surfaces.

In another embodiment, an embossed substrate, after deposition of the light-sensitive layer(s), has a protective hardcoat applied over the last layer. This can be done in the vacuum chamber, where the hardcoat is an inorganic material or blend of materials. Additionally, this can be done by the method known to the art of applying a cross-linkable photopolymer material *in vacuo* to the deposited layers as described previously, and exposing the material to a source of radiation, such as an ultraviolet light source or electron beam source, that is capable of activate crosslinking of the polymeric material.

In a related embodiment, the thickness and smoothness of the applied polymeric overcoat layer can be suitably modified by laminating the overcoated substrate, while still in the liquid state, against a suitably transparent surface, such as in the form of a roll or platen, while under suitable pressure, and effecting the crosslinking process by exposure of the laminate to radiation through said surface. The surface texture of the roll or platen can be such that, upon crosslinking and subsequent separation, the outer surface of the media of this disclosure has a replica of the desired surface texture. This is useful for light control and/or friction control, among other things. If the overcoat is electrically conductive, such as by the use of a conductive inorganic or polymeric material, then such a coated surface can also provide static electricity dissipation.

It is an aspect of this disclosure that the preformatting and subsequent coating operations can be done on a substrate whose width is that of the desired product, such as 1/2-inch or 35 mm , etc. It is also desirable in other circumstances to make the substrate in wide widths, such as from several inches to several meters in width, and after the coating step, cut the wide roll into narrower widths, typically known to the art as slitting. In an embodiment of the slitting operation, the preformat pattern may be used with an optical pickup unit to track the material during the slitting operation and to use the electronic signal so generated to provide feedback to a web guide or the like on the slitting machine to allow precise division of the master substrate roll. This is useful when it is necessary or useful that slit edge be registered with a particular section of the master pattern, such as for example where the outer portion of each finished tape correspond to a particular edge guide section of the pattern.

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DRAWINGS

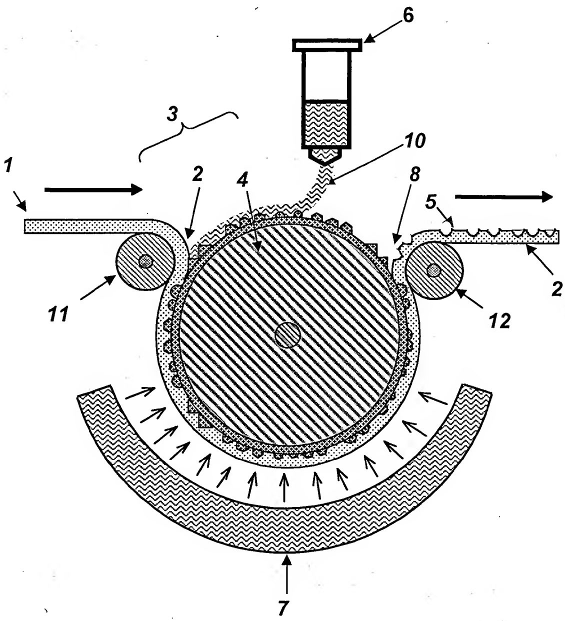

Fig 1

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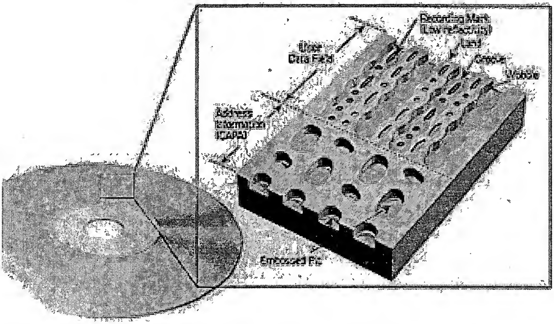

Fig. 2a (prior art)

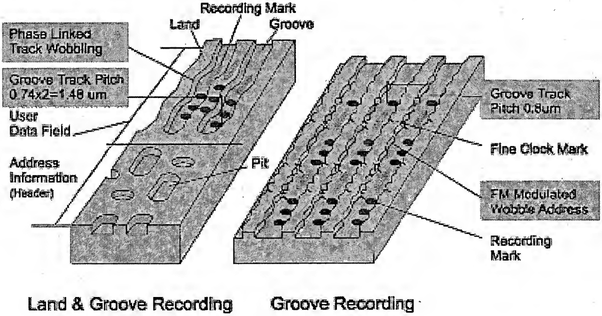

Fig 2b (prior art)

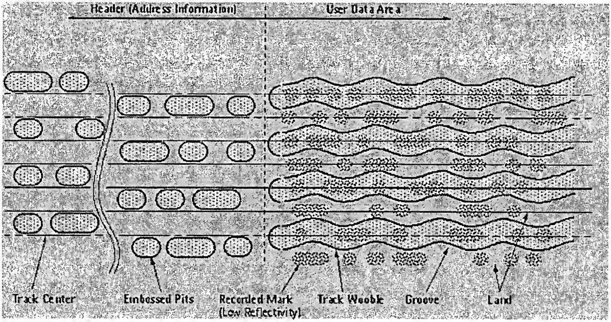

Fig 3 (prior art)

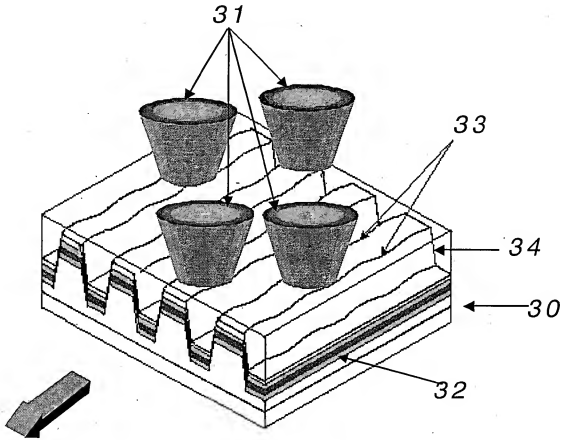

Fig 4

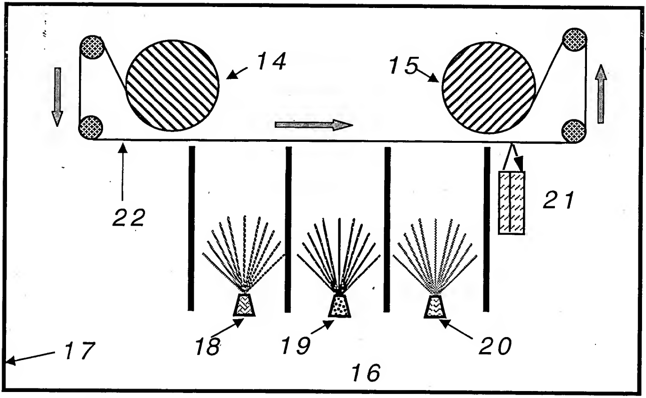

Fig 5